On the Origin of Narrow, Very Long, Straight Jets from Some Newly Forming Stars

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ABSTRACT

Observations have shown the existence of narrow, very long, straight jets emitted by some newly forming stars (1). It is highly likely that stars forming in the plane of a spiral galaxy do so in the presence of an almost uniform magnetic field. In the Strong Magnetic Field model (SMF), gravitational collapse of a highly conducting plasma in the presence of such a field will result in the formation of a stable, highly relativistic current loop (storage ring) around the central object. The concept was first described by Greyber (2-14). In the figures in Mestel & Strittmatter (15), one can see such a storage ring beginning to form. Such an increasing dipole magnetic field (formed temporarily for 10^4 to 10^6 years) will produce, accelerate and confine a narrow, very long, straight jet. When the density becomes too high, either the loop is destroyed, or the current-carrying plasma ring is buried inside the newly forming star and is the source of primordial stellar magnetism.

1. Introduction

The famed physicist Enrico Fermi introduced equipartition into astrophysics in the Forties, and did it right. He discussed shock waves, and obviously turbulence close to the shock made equipartition a reasonable assumption there. However astronomers soon forgot the caveat, i.e. that there was no reason to assume plasma turbulence producing equipartition must exist everywhere in astrophysics. Thus, the very small magnetic fields, often deduced and published, from assuming equipartition, are irrelevant in many situations. Actually equipartition applies only when the physics demands it does!italics?

Thus, for almost four decades, there has been a widespread misconception that "equipartition" between the particle energy and the magnetic field energy was absolutely necessary in most astrophysical situations. Very strong cosmic magnetic fields are accepted as real in white dwarfs and neutron stars. However until recently it has been alleged that strong magnetic fields could not exist in the cores of quasars and active galactic nuclei (AGN), nor in newly forming stars.

For 35 years, the Strong Magnetic Field model, Greyber (2-14), has argued forcefully for what Chi and Wolfendale (16) wrote recently. "there is, however, no compelling justification for this assumption of equipartition". Originally created to explain spiral arms and answer Oort's famous questions, SMF has since been applied to the physical model of the central engine of AGNs, jet formation, galactic energetics and morphology, gamma ray bursts, etc.

2. The Strong Magnetic Field Model (SMF)

Greyber (17) has proposed an original model, within the Big Bang hypothesis, involving cosmical magnetism as well as gravitation, that explains the origin of large-scale primordial magnetic fields, as well as the origin of the observed highly structured nature (thin sheets of galaxies and voids) of matter in the Universe. Note that Pietronero et al (18) conclude, "galaxy correlations are fractal and not homogeneous up to the limits of the available catalogues".

Kosowsky and Loeb (19) recently emphasized "The origin of the primordial field is still a subject of speculation. In the past, various indirect theoretical arguments were used to favor the dynamo amplification mechanism over the primordial origin alternative. However recent studies argue that a galactic dynamo should saturate due to the rapid growth of a fluctuating small-scale field before it can actually result in a coherent large-scale field of the type observed in galactic disks. The view that the galactic field may, in fact, be primordial

gains additional support from observations of damped Lyman absorption systems in QSO spectra at Z 2. The potential existence of a primordial magnetic field is also consistent with observations of clusters of galaxies. Faraday rotation measurements of radio sources inside and behind clusters indicate strong magnetic fields in many of them."

When one considers a galaxy or quasar forming by gravitational collapse of a giant, highly conducting, plasma cloud containing an almost uniform primordial magnetic field, SMF argues that a new physical construct, a storage ring, is created. Since the topology is very similar, the very same process occurs during the formation of a star under gravity. The gravitationally bound current loop, or storage ring, is extremely intense and highly relativistic. The bursting force of this very strong unified magnetic field system is in equilibrium, balancing the gravitational force between the slender toroidal plasma (bound to the current loop in side the very slender toroid by the Maxwell "frozen-field" condition), and the central massive object.

The morphology and energetics of objects of galactic dimension are determined in SMF by the ratio of magnetic field energy to rotational energy in that particular object. The ratio is extremely high for quasars and blazars, and decreases steadily for giant elliptical and radio galaxies, Seyferts, Markarians, is low in ordinary spirals and is close to zero for the ordinary elliptical galaxies. However it is important to note that the AGN activity we now observe is a function of the accretion of matter into the central engine of the object.

A diagram of the SMF central engine for AGN is in references (10) and (14). It is the same for around a newly forming star, except that the central mass concentration is the protostar. High energy particles in this completely coherent, relativistic current loop store a significant fraction of the huge energy of gravitational collapse. The dipole magnetic field bound to the protostar probably contributes to the loss of angular momentum of the contracting protostar.

One can see such a storage ring forming in the figures in a brilliant, pioneering paper by Mestel and Strittmatter (15). They analyzed the effect of Ohmic diffusion on the magnetic field distribution of a gravitationally bound magnetic gas cloud, illustrating how the magnetic field topology changes as the cloud field detaches from the background field.

A storage ring, once formed, is uniquely stable. Due to coherence, one part of the loop does not radiate in the magnetic field of another part. However, if a fluctuation or "bump" occurs somewhere along the loop, the electro ns in the "bump" will suddenly radiate furiously in the immensely strong local magnetic field, the energy in the fluctuation will dissipate rapidly, and the storage ring will return quickly to its undisturbed configuration. A relevant point is that the largest external perturbation to a storage ring is limited to solid

matter, i.e. objects not much larger than the planet Jupiter, since stars, made of plasma, would break up before penetrating close to the intense magnetic field of the loop.

Klein and Brueckner (20) investigated the motion of a plasma under the action of an increasing magnetic field from a stationary coil. They found that the efficiency of conversion of stored energy into kinetic energy was about 5-10%. A simil ar or greater efficiency is then expected in SMF for the expulsion of the extremely high conductivity plasma from around a newly forming star, forming a jet. The increasing dipole magnetic field, as the contraction under gravity forming the star continues, accelerates and keeps the plasma jet narrow and confined for extremely long distances from the protostar.

The SMF model predicts that jets are formed by the successive emission of blobs of plasma from the AGN or stellar "central engine". Jets composed of blobs of plasama are just what is observed, both in jets from galaxies and quasars, and also observed as well in some newly forming stars like HH-30, which has been observed recently with HST.

3. Conclusion

The fact that jets are not well defined in many newly forming stars is understandable considering the relatively high density of the plasma in the vicinity of the protostar, and the disruption to the storage ring that may occur from binary o r multiple prot ostars forming in close proximity. When the plasma density becomes too high, either the storage ring is destroyed, or, in some instances, the current-carrying plasma loop is buried inside the newly forming star and is the source of primordial stellar magnetism.

Evidence for the storage ring of current around some newly forming stars, with narrow, straight, long jets, hopefully will be found as observational resolution improves. This would be very important because it would validate the same topology as applied to the physics of the central engine of quasars and galaxies. So far, the SMF model appears to fit the observations.

4. References

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